Two shift operation power plants

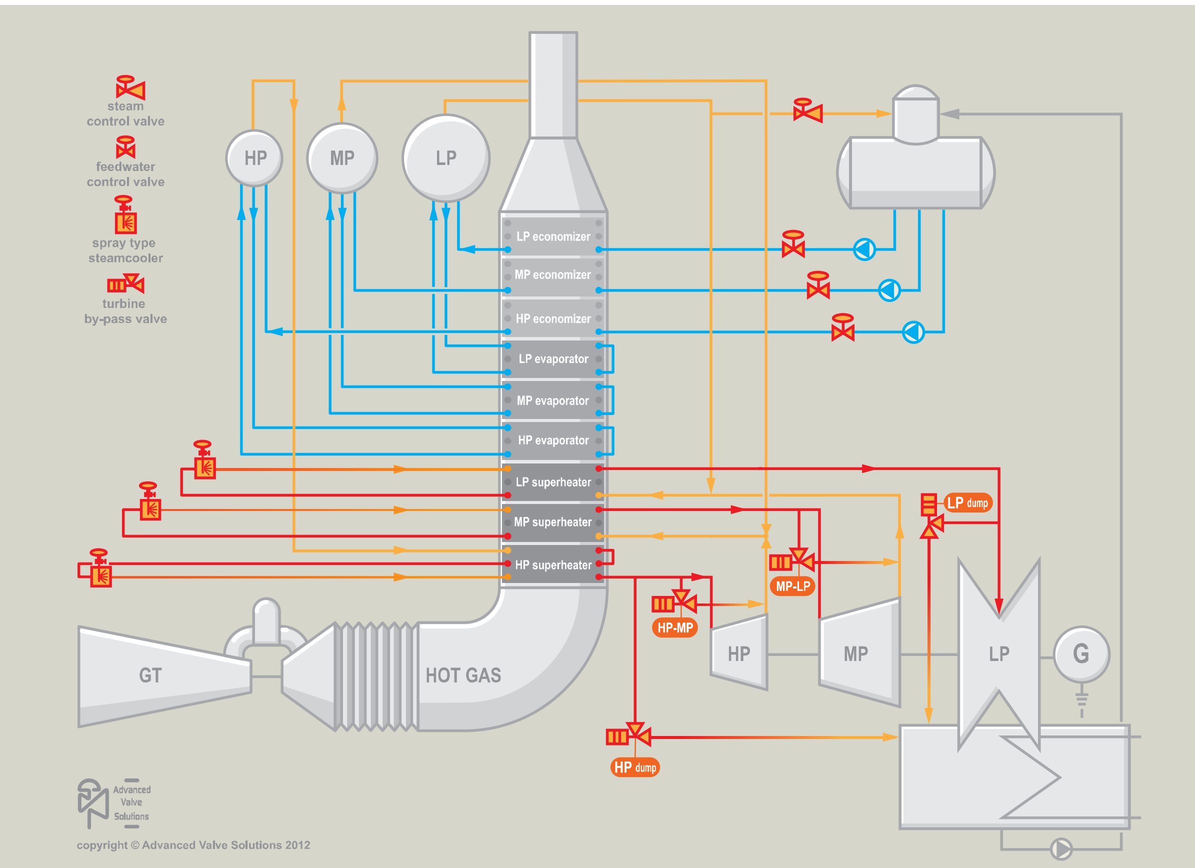
Power stations that were originally designed for base load applications are now increasingly being asked to operate on a two shift, stop/start regime; this is more commonly known in the industry as dual shifting. The multiple start/stops that these stations are now experiencing are in some instances causing an increase of operational issues due to the constantly changing process parameters. For example dual shift stations will experience additional thermal stress in the headers, drums, high temperature piping, valves plus the auxiliary equipment leading to additional wear and tear of their systems and component parts. This is due to the more frequent use of the plant at severe service conditions. The consequences of the change in plant operation cannot be ignored. If the plant is not operated correctly, or more importantly modified properly to handle these changes, the lifetime of the components within the plant will decrease enormously.

The changing operational requirements of the plant require that the steam coolers, de-superheater valves, drains, feed water control valves, main steam isolation valves and the turbine quick closing valves are reviewed. These critical pieces of equipment have to be specifically designed to take the new dual shifting process requirements into consideration. Once this has been done the operational performance of the plant can be improved and wear and tear of systems and components can be controlled and significantly reduced. Consequently as these pieces of equipment have been specifically designed for the new operating conditions of the station they are no longer a limiting factor to the start up time of the plant.

The following paper highlights some of the more common issues found in dual shifting power stations with special regards to steam control.

Pressure reducing de-superheater stations (PRDS)

In the energy markets for example, power stations, paper mills, municipal waste incinerators or any steam raising plants, the control of steam is of crucial importance. The main function of a PRDS is to control both the pressure and temperature of the steam. A de-superheater valve is basically a control valve with an integrated spray water steam cooling facility.



HORA pressure reducing de-superheater stations are designed to have:

- A very precise temperature control,
- A wide rangeability,
- The capability to cool close to saturation.
- The spray of cooling water, depending on the main steam flow is done in a way to avoid thermal shock and to optimise the cooling effect, both quickly and precisely.
- Easy change trims without having to remove the whole valve from the process line-simple to maintain.
- Low noise levels, based on an in-depth knowledge of the valves and their inherent characteristics.
- The ability to be built in accordance to TRD 421 and to be used as a safety device.
- Quick opening and / or closing as standard.
- Pneumatic, hydraulic or electrical actuation.

Every application is different and requires a custom built solution. A standard "off the shelf valve " is rarely the answer. HORA can produce all types of steam cooling devices and de-superheater stations. Every HORA valve is designed and optimised for the specific application and duty.

From base load to start-stop

Installations built for base load applications have a fairly constant set of process conditions. The systems and components used to start and stop the installation are operated within their design capacity. Components such as de-watering valves, start-up control valves and de-super heater / turbine by pass valves (PRDS) are not working once the installation is on line. Changes in the plants operating regime to dual shifting does mean that the installed systems and components are now more intensively used, some on the limit of their design capacity.

To cope with these start-stop challenges AVS has, together with their manufacturers, developed a number of solutions. Combi-feedwater control valves, sophisticated drain valves, steam coolers with a wide rangeability, low noise de-super heater valves with better temperature control, thin walled forged stop valves and quick closing turbine extraction valves, these have all been designed with the rigours of the dual shifting station in mind.

Pressure reducing de-superheater control valves.

De-superheater control valves are located between the steam turbine the HP and MP lines, between the MP and LP and from the LP to the condenser.
The older style PRDS valves inject water in the seat area and do not control the droplet size of the water. This can result in thermal shock within the system; the absence of precise temperature control will lead to excessive wear and tear in the valves and the downstream piping. If the valves are rarely operated (as in full load conditions) this is not seen as a problem but in a start/stop regime this could easily lead to severe damage to components within the plant. Crucial to the design of the valve is noise attenuation and the rangeability. A wide rangeability and low noise levels are issues these specialist designed valves have solved.
Desuperheating solutions are sometimes bought as "off the shelf "process valves, designed to work in process plants on full load continuous operations, however they do not perform well on a start /stop cycle.

To build a bypass valve which can be operated continuously or for many hours over a day the focus of the design has to be more on the way the cooling water is atomized, the rangeability of the valve and the noise attenuation produced by the valve.
Special attention is needed when the PRDS control valve is also performing a safety function. Please see TRD 421.

Different ways of cooling

There are different ways to inject the cooling water into the hot steam.
The most crucial element however is the water droplet size. In all cases the droplets have to be as small as possible. A small droplet will evaporate very quickly and should it come in contact with material such as the pipe wall the thermal shock will be kept to a minimum.

There are different methods to achieve fine atomising:

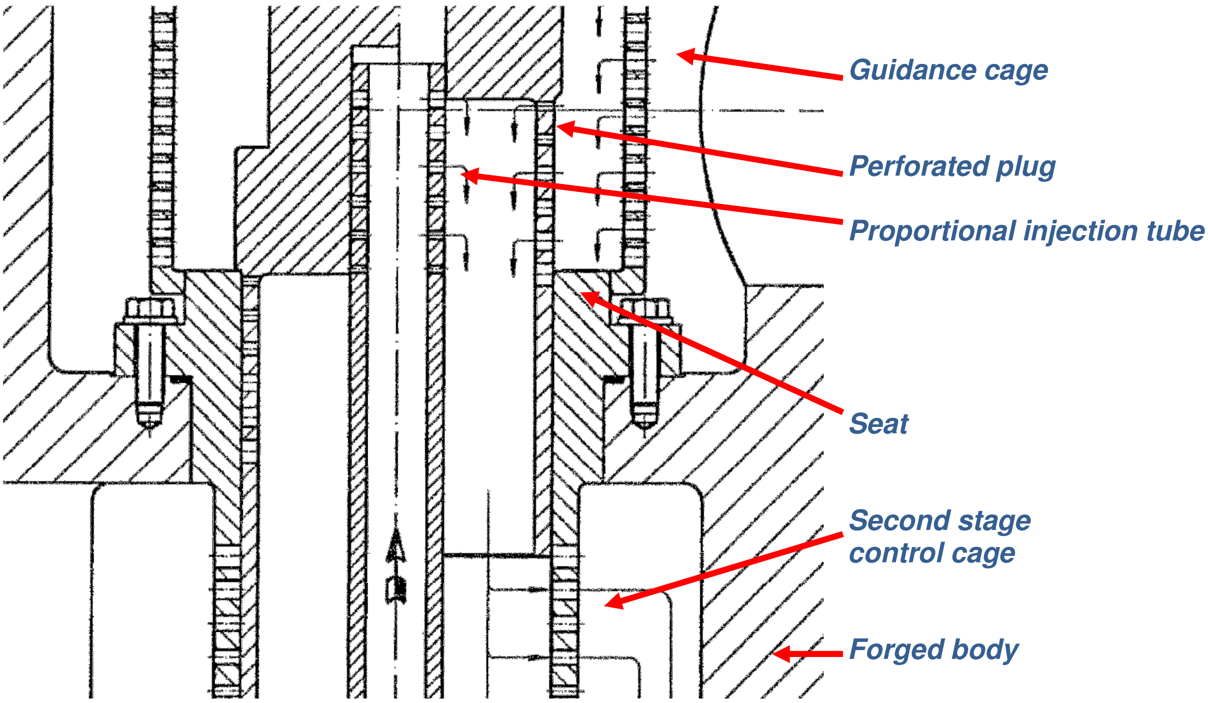
A. To ensure small droplets there has to be a sufficient pressure drop over the full range ability of the valve. This is done by "proportional injection".

B. An other method to ensure correct droplet sizes is the use of critical expanding steam to atomize the cooling water. Valves with a steam atomizer are using this principle.

C. The use of spring loaded nozzles is in some cases a solution as well.

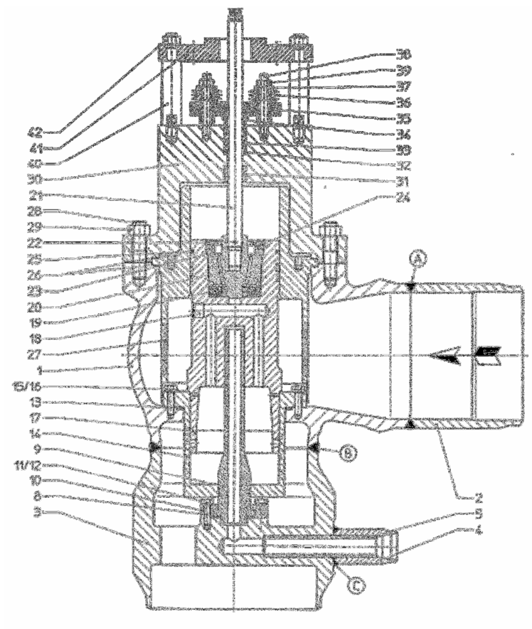
Proportional injection

A way of bringing the cooling water into the steam is by proportional injection.
A perforated pipe is placed in the centre of the perforated plug. The plug is covering all the holes in the central injection tube.
Lifting the plug opening steam reduction holes from the plug AND in proportion water injection bores from the central injection tube.
In this respect a correct balance in CV value between steam and water pressure drop is always maintained throughout the range.
This water pressure drop guarantees the creation of small droplets. These droplets are brought into the most turbulent part of the valve, which will minimize the droplet size even more. The result is extremely quick evaporation.

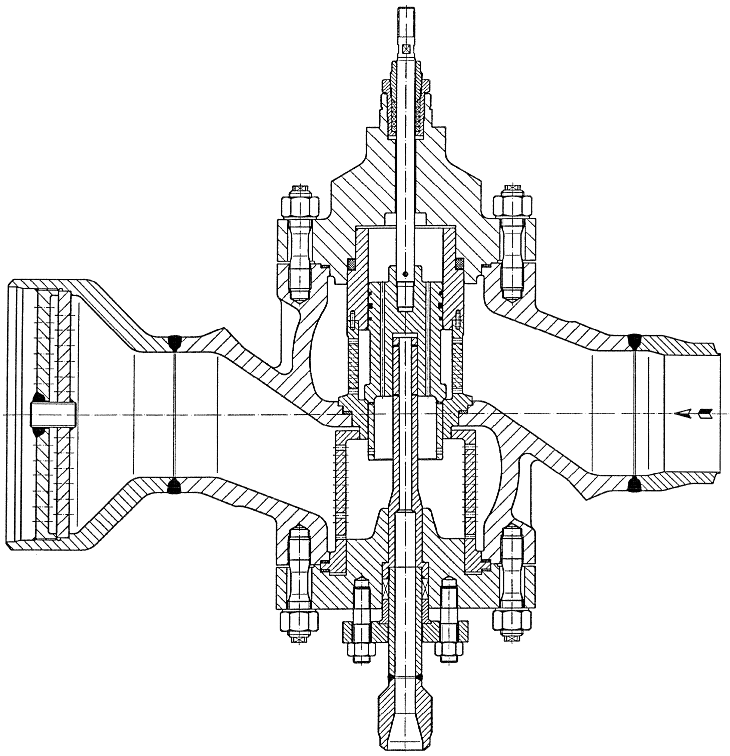


This trim design is used in forged body designs as well as in cast valves. The advantage is the optimal mixing of the cooling water into the steam. The water pressure drop creates small droplets, injected in the most turbulent part of the valve, followed by cages and throttling plates.

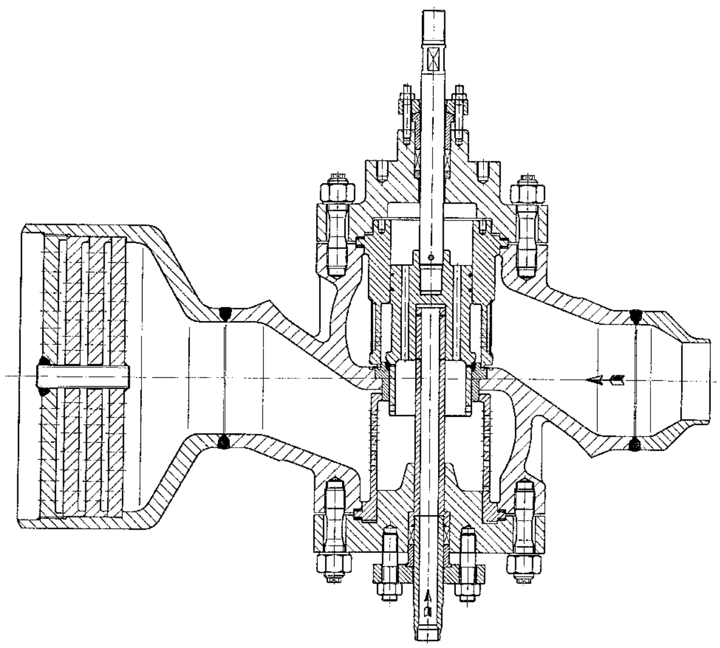
In this method it is possible to build numerous different versions to match exactly the requirements of the end user.

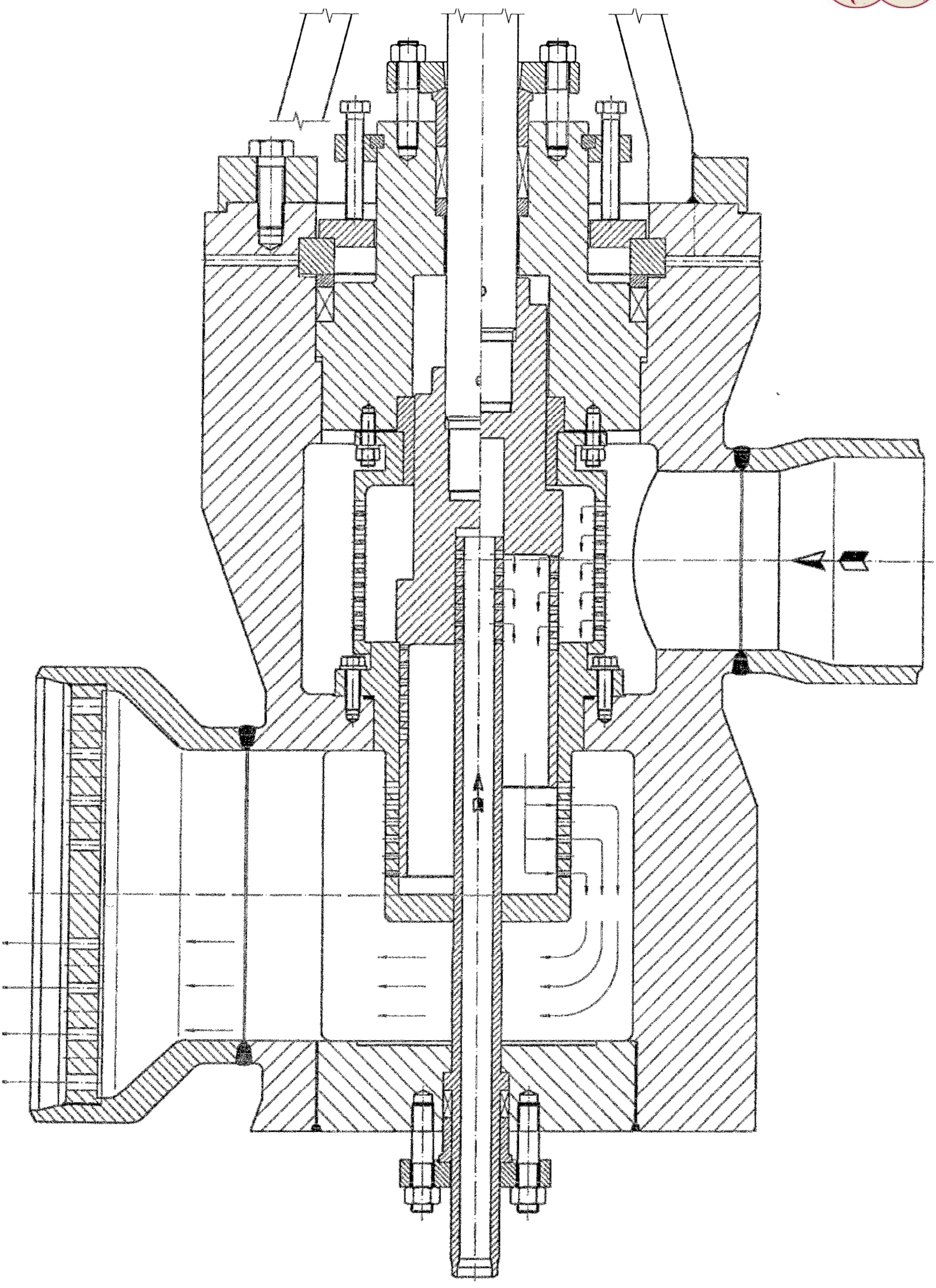


Left:
Angle type de-super heater control valve, cast body, bolted bonnet, proportional injection, balanced plug with pilot plug, controlled cage in the outlet.



right and below:
cast de-super heater control valves, proportional injection, balanced plug, jammed seat outlet cage, increased outlet size, 2 or 4 throttling plates.





Above:
De-superheater control valve, forged body, Z form, pressure seal, bolted seat, inlet guide cage, perforated plug with proportional water injection, controlled cage in the outlet, 1 throttling plate, in the outlet.

Cooling with integrated steam atomising unit

De-super heater control valves fitted with a steam atomising unit are manufactured for extreme applications. Throughout the whole range ability the atomising steam is giving the finest droplets. Optimal cooling is the result

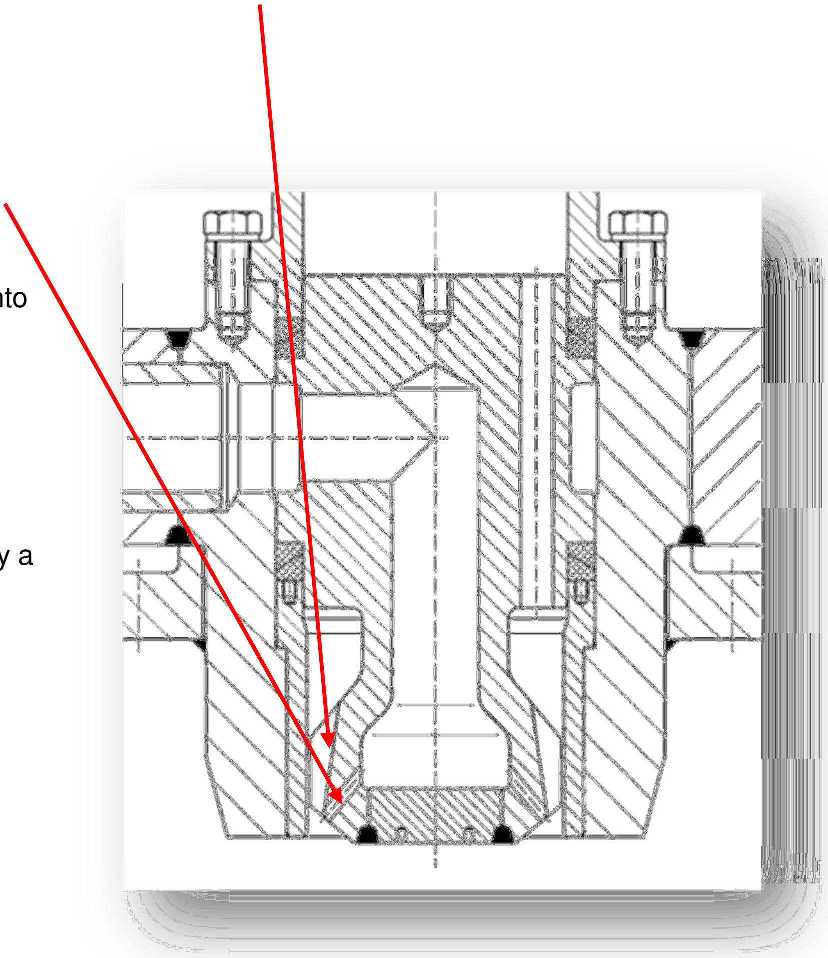
- Cooling close to saturation is possible
- A high steam – cooling water ratio is achievable
- No limitations on the steam mass flow
- The required cooling water pressure is low, just a few bar above the downstream steam pressure.
- The water is carefully injected in the piping, not touching any hot part of the control valve.

The function of the steam atomizer is simple

Directly downstream the first pressure reducing stage a small quantity of atomizing steam is guided through the bores of the atomizing unit.
The critical path is formed by the bores in the outlet of the head. The critical expanding steam Is reaching it's highest velocity at the end of the tapered channel.

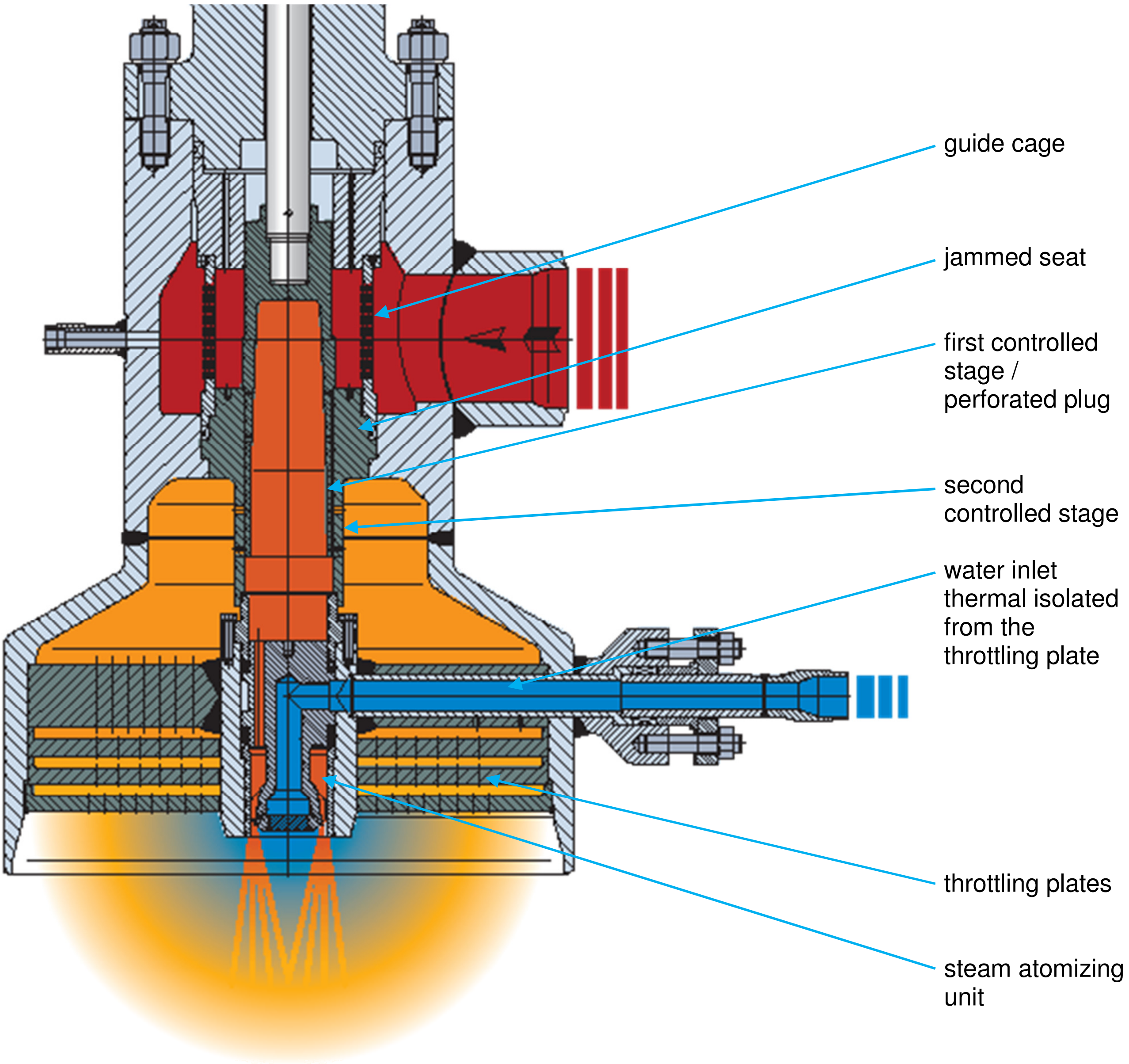
Through small holes water is injected into the critical expanding steam. The enormous velocity of the steam is "crashing" the water into very fine droplets. The steam velocity guarantees as well a distribution throughout the downstream piping. This results in a quick cooling steam mass flow.

The cooling water flow is controlled by a separate control valve.



Turbine by pass valve with steam atomizer

The above described steam atomizing unit is integrated in a turbine by pass valve, a PRDS (pressure reducing de-superheating) valve. These valves are used to protect steam turbines and are operating at start up and shut down of installations. The valves are ured as well to “balance” different pressures in steam grids. A good range ability and low noise performance and good maintainability are necessary.



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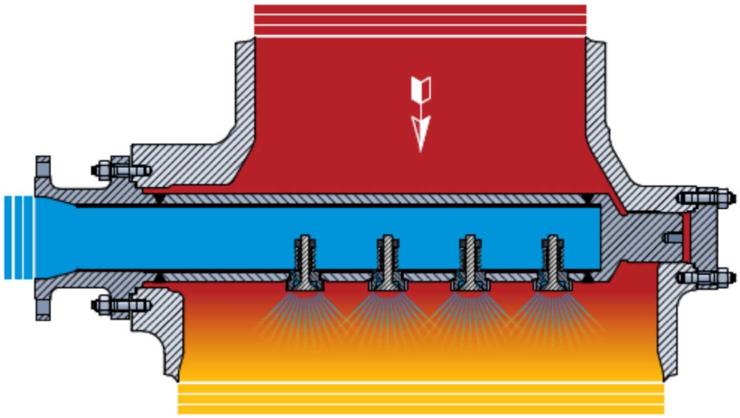
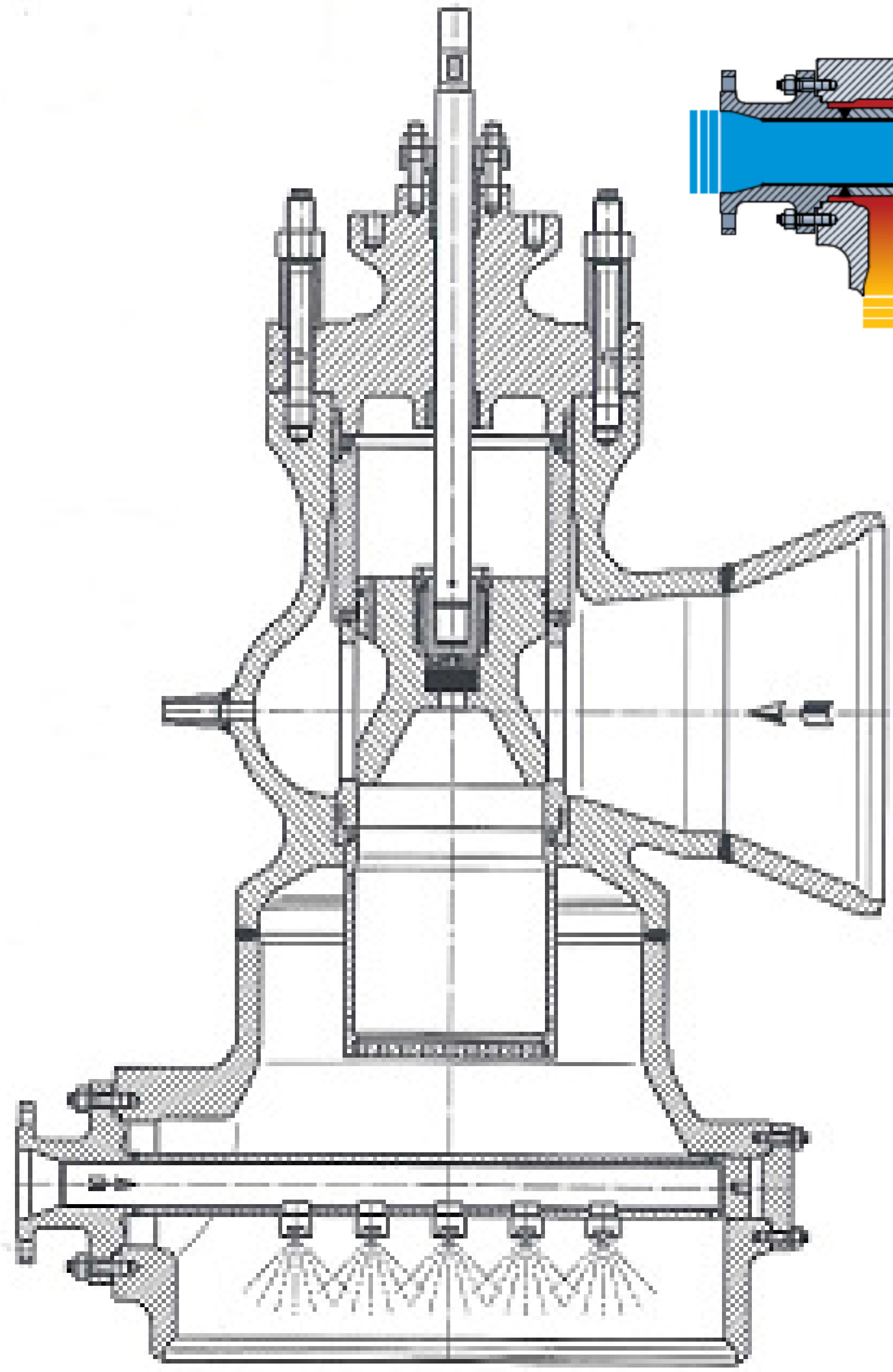
In the show valve above we see a 6 stage pressure reduction, based on 2 controlled stages and 4 throttling plates. The steam cooling is done with a steam atomizing unit, positioned in the centre of the valve.
The valve body is based on a forging, bolted bonnet, and a jammed trim for easy maintenance.

Nozzle injection:

To inject enough cooling water into the steam flow, for example in a dump valve to a condenser, often nozzles are used.
A nozzle can spray a mass flow of cooling water into the steam. The controllability can be improved by using spring loaded nozzles with different spring characteristics which are opening one by one, depending on the water pressure.

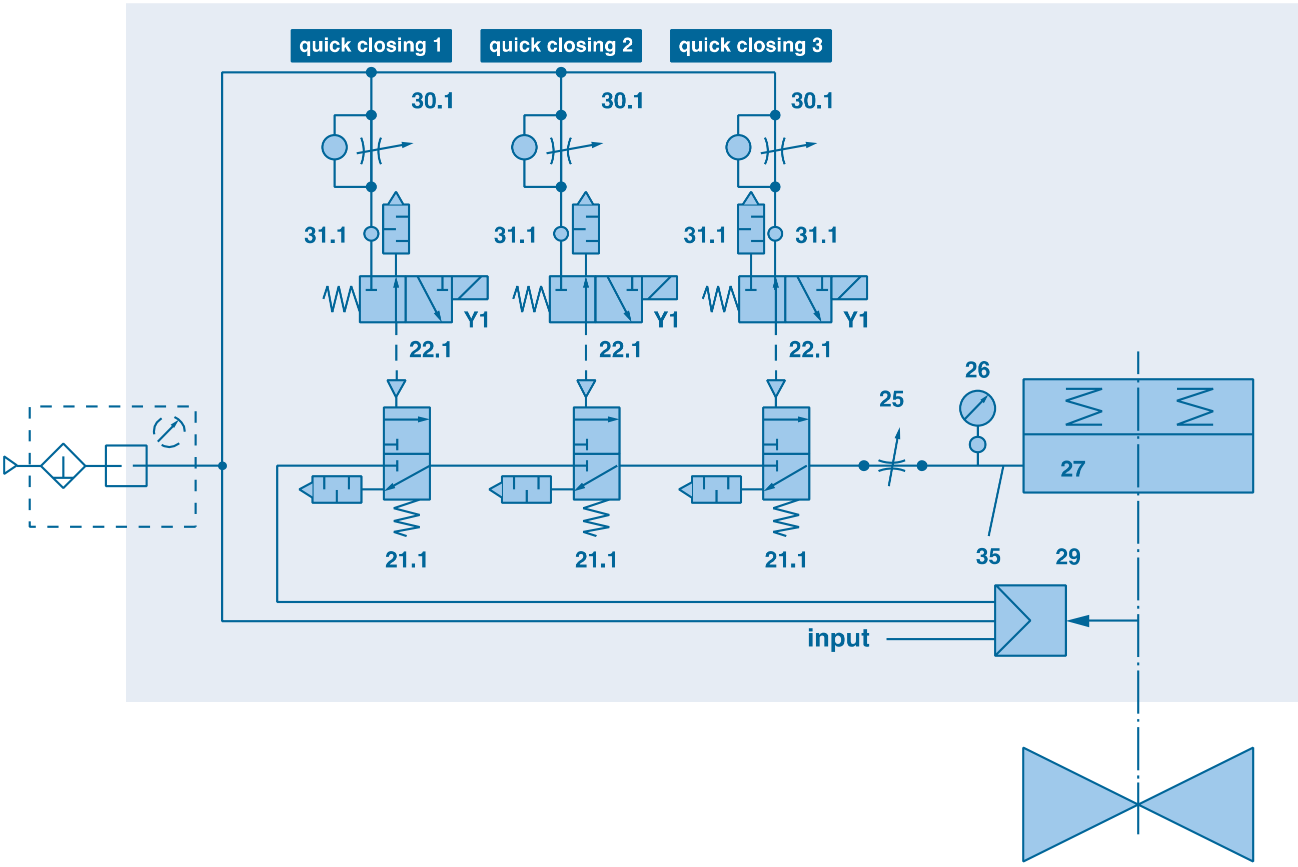




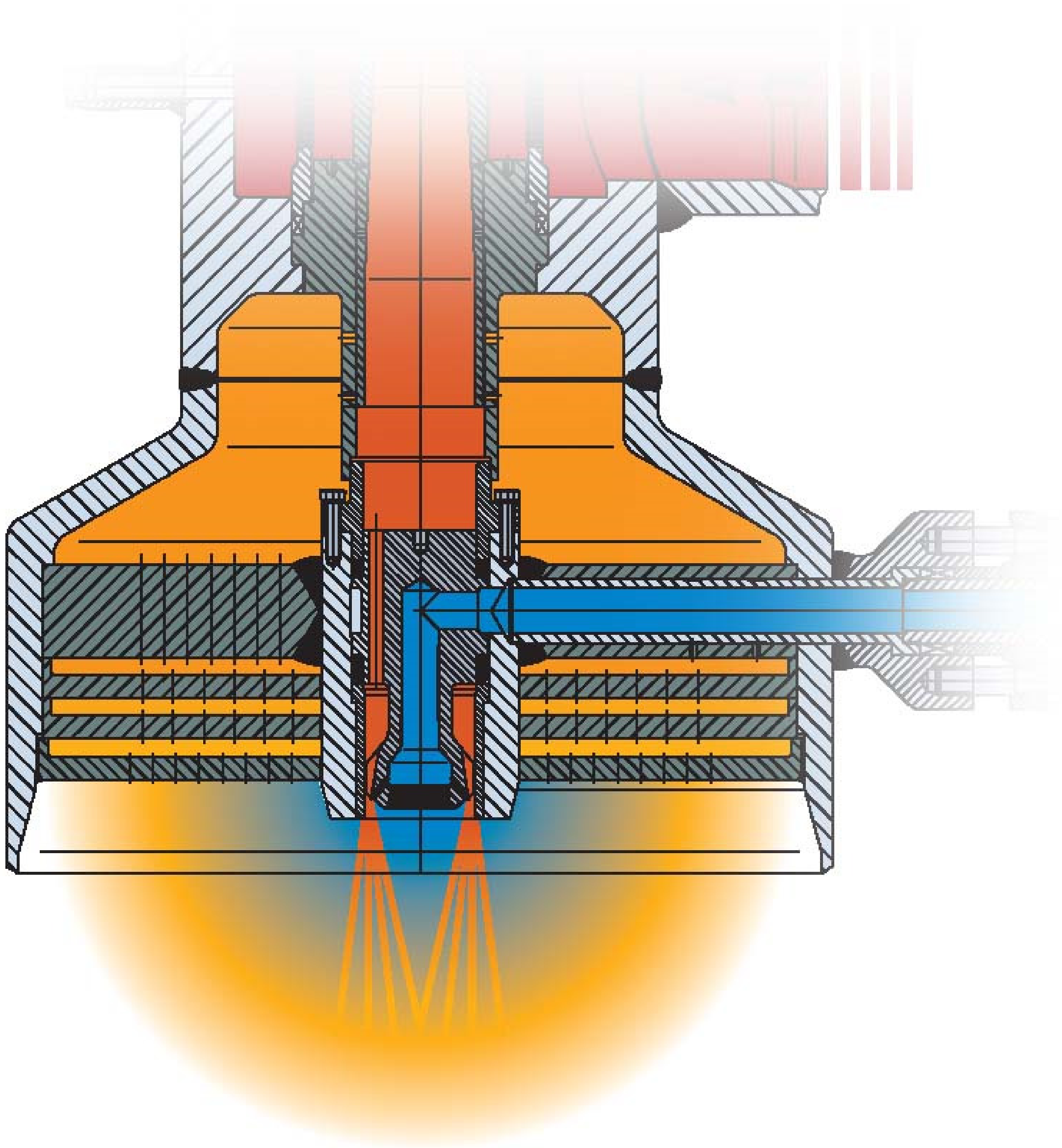
Left:
LD turbine bypass, cast body, balanced plug, outlet cone with spring loaded nozzle type water injection.

TRD 421 / EN 12952 - 10

Within the EN rules and regulations a safety system is described and approved. Under strict rules a control valve can be used as a safety device as well.
The system is based on a triple redundant pressure transmitter which is giving a signal to the actuator of the control valve.
The actuator is a pneumatic or hydraulic spring to open or spring to close type. In case the pressure transmitter is generating a signal, the control function of the over ruled and the actuator is following the spring function.
To protect high pressure steam boilers a additional requirement is the flow “tending to open” construction of the main control valve.



Schematic showing a quick closing device based on EN 12952-3 / TRD 421. The 3 quick pneumatic valves discharge the air from the “spring to close” pneumatic actuator and are also closing the air supply from the positioner when the quick closing valves are activated.



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